electrons which are then accelerated toward the anode 24. The anode 24 attracts the electrons, but passes them through its central aperture toward the target assembly 26. The controller 12C controls the power supply 12A to dynamically adjust the cathode voltage, the electron beam current, and temporal parameters, or to provide pre-selected voltage, beam current, and temporal parameters.

Also illustrated, is an alternative electron beam generator which includes a photoemitter 22 irradiated by a light source 56, such as a diode laser or LED, powered by a driver 55. The light is focused on the photoemitter 22 by a focusing lens 58.

In the illustrated embodiment, external telemetry device 52 and telemetry network 12E cooperate to permit external control (dynamic or predetermined) control over the power supply 12A and temporal parameters. In embodiments when the housing 12" is not implanted, but where only probe 14 extends into a patient's body, the controller 12C may directly be used to control operation and in that case there is no need for network 12E.

FIGS. 5 and 6 show a diagrammatic view of radiation treatment apparatus 200 including a flexible probe 214. The apparatus 200 includes a high voltage source 218, a laser (or other optical) source 220, a probe assembly 214, and a radiation source assembly 226. According to one aspect of the invention, the apparatus 200 provides the required flexibility, without using strong magnetic fields, by locating electron source components 222, 223 and accelerator 224 near the target 228 in the distal end of the probe 214. The probe assembly 214 couples both the laser source 220 and the high voltage feed 218 to the radiation source assembly 226. Preferably, the probe assembly includes flexible fiber optical cable 202 enclosed in a small-diameter flexible metallic tube 204.

The radiation source assembly 226, which can be for example 1 to 2 cm in length, extends from the end of the probe assembly 214 and includes a shell which encloses the target 228. According to one embodiment, the radiation source assembly 226 is rigid in nature and generally cylindrical in shape. In this embodiment the cylindrical shell enclosing the radiations source assembly 226 can be considered to provide a housing for the electron beam source as well as a tubular probe extending from the housing along the electron beam path. The inner surface 226A of the assembly 226 is lined with an electrical insulator, while the external surface of the assembly 226 is electrically conductive. According to a preferred embodiment, the radiation source assembly is hermetically sealed to the end of the probe assembly 214, and evacuated. According to another embodiment, the entire probe assembly 214 is evacuated.

The terminal end 202A of the fiber optical cable 202 is preferably coated, over at least part of its area, with a semitransparent photoemissive substance such as, Ag—O—Cs, thus forming a photocathode 222. A high voltage conductor 208, embedded in the fiber optical cable 202, conducts electrons to the cathode 222 (if necessary), the electron multiplier 223 and the accelerator 224 from the high voltage source 218. Similarly, the flexible tube 204 couples a ground return from the target 228 to the high voltage source 218, thereby establishing a high voltage field between the cathode 216 and the target 228. The fiber optical cable 202 acts as an insulating dielectric between the high voltage conductor 208 and the grounded flexible tube 204.

In order to eliminate scattering of the light in the fiber optic cable 202 by the high voltage wire 208, the fiber optic cable 202 can have an annular configuration. The light from the laser 220 travels down the annular core of the fiber optic cable 202. Cladding can be provided on each side of the core having an index of refraction so as to reflect the light beam incident on the interface back into the core. The grounded flexible metal tube 204 can surround the outer cladding.

As in previously described embodiments, the target 228 can be for example, beryllium, (Be), coated on one side with a thin film or layer 228A of a higher impedance element, such as tungsten (W) or gold (Au).

In operation, the small semiconductor laser 220 shining down the fiber optical cable 202 activates the transmissive photocathode 222 which generates free electrons 216. The high voltage field between the cathode 222 and target 228 accelerates these electrons, thereby forcing them to strike the surface 228A of target 228 and produce x-rays. In order to generate, for example, 20 uA of current from an Ag—O—Cs photocathode 222 with a laser 220 emitting light at a wavelength of 0.8 m, the 0.4% quantum efficiency of this photocathode 222 for this wavelength requires that the laser 220 emits 7.5 mW optical power. Such diode lasers are readily commercially available. According to the invention, the photoemissive surface which forms cathode 222 can, in fact, be quite small. For example, for a current density at the cathode 222 of 1 A/cm^2, the photoemitter's diameter need only be approximately 50 µm.

One difficult fabrication aspect of this invention is the fabrication of the photocathode 222, which for practical substances, with reasonable quantum efficiencies above 10^{-3}, should be performed in a vacuum. This procedure can be carried out with the fiber optical cable 202 positioned in a bell jar, where for example, an Ag—O—Cs photosurface is fabricated in the conventional manner. Subsequently, without exposure to air, the optical cable 202 can be inserted into the tube 204. The end 202B can be vacuum sealed to the flexible tube 204.

In the above embodiments, the probe 14 or 214, along with its associated target 26, or 228, can be coated with a biocompatible outer layer, such as titanium nitride on a sublayer of nickel. For additional biocompatibility, a sheath of, for example, polyurethane can be fitted over the probe, such as that illustrated in FIG. 3.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of the equivalency of the claims are therefore intended to be embraced therein.

What is claimed is:

1. A therapeutic radiation source, comprising:

A. a flexible catheter extending along a probe axis between a proximal end and a distal end of the catheter, the flexible catheter comprising optical delivery means extending along said probe axis and having an originating end and a terminating end, and adapted for transmitting optical radiation incident on said originating end to said terminating end;

B. an optical source, including means for generating a beam of optical radiation directed to said originating end of said optical delivery means;

C. a radiation source coupled to said terminating end of said optical delivery means, comprising a substantially rigid housing enclosing an electron source and a target, said housing defining a substantially evacuated interior

region extending along a beam axis between said electron source at an input end of the housing and a radiation transmissive window at an output end of the housing,

a. wherein said electron source and said target are disposed along said beam axis and spaced apart from and opposite each other;

b. wherein said electron source is adapted to emit electrons in response to optical radiation transmitted to said terminating end, and comprises a thermionic emitter having an electron emissive surface; and

c. wherein said target is responsive to incident electrons to emit therapeutic radiation whereby therapeutic radiation emitted therefrom is directed through the radiation transmissive window; and

D. means for establishing an accelerating electric field extending between said electron source toward said target, the electric field acting to accelerate electrons emitted from said electron source toward said target;

wherein said optical delivery means are adapted for directing a beam of optical radiation transmitted therethrough to impinge upon said surface of said thermionic emitter, and wherein said beam of transmitted optical radiation has a power level sufficient to heat at least a portion of said surface to an electron emitting temperature so as to cause thermionic emission of electrons from said surface.

2. A therapeutic radiation source according to claim 1, wherein said optical source is a laser, and wherein said beam of optical radiation is substantially monochromatic and coherent.

3. A therapeutic radiation source according to claim 1, wherein said therapeutic radiation comprises x-rays.

4. A therapeutic radiation source according to claim 1, wherein said optical delivery means comprises a fiber optical cable assembly having a fiber optical element extending from said originating end to said terminating end.

5. A therapeutic radiation source according to claim 4, wherein the means for establishing an accelerating electric field comprises:

a power supply, having a first terminal and a second terminal, and a drive means for establishing an output voltage between said first terminal and said second terminal, said power supply being electrically coupled to said radiation source by way of said first terminal and said second terminal.

6. A therapeutic radiation source according to claim 4, wherein said fiber optical cable assembly further comprises:

A. an electrically conductive cable, wherein said fiber optical element is concentrically disposed around said electrically conductive cable; and

B. an electrically conductive outer shell, concentrically disposed around said fiber optical element, said fiber optical element forming an optically transmissive core.

7. A therapeutic radiation source according to claim 6, wherein said fiber optical cable assembly further comprises a first cladding shell, said first cladding shell having an index of refraction less than the index of refraction of said optically transmissive core and being concentrically disposed between said electrically conductive cable and said fiber optical element.

8. A therapeutic radiation source according to claim 7 wherein said fiber optical cable assembly further comprises a second cladding shell, said second cladding shell having an index of refraction less than the index of refraction of said optically transmissive core and being concentrically disposed between said fiber optical element and said electrically conductive outer shell.

* * * * *

<u>**CLAIMS ADDED TO REISSUE APPLICATION**</u>	<u>**ASSERTED SUPPORT IN SPECIFICATION OF '932 PATENT**</u>	<u>**DESCRIPTION**</u> (boldface added)	<u>**FIGURES**</u>
9. (New) A vascular probe having an X-ray tube as a distal end, comprising: a flexible optical fiber having a bore through its length, a first electrical conductor extending through the bore of the optical fiber,	col. 1, lines 11-15; col. 2, lines 17-19; col. 2, lines 27-29; col. 2, lines 32-37; col. 3, lines 25-27; col. 7, lines 33-35; col. 7, line 55 – col. 8, line 2	"The present invention relates to a highly miniaturized, low power, programmable radiation source . . . and more particularly to a miniaturized radiation source mounted in a **flexible probe**." (col. 1, lines 11-15) ". . . it is desirable to have **a flexible tube leading to the x-ray emitting target** . . . " (col. 2, lines 17-19) ". . . It is a further object of the present invention to provide an improved highly miniaturized radiation source with a flexible probe." (col. 2, lines 27-29) ". . . The present invention is directed to **a miniaturized radiation source at the end of a flexible probe or catheter**. The flexible catheter extends along a probe axis between a proximal end and a distal end of the catheter. **The radiation source, at the distal end of the catheter,** . . . . " (col. 2, lines 32-37) ". . . **the radiation source can be disposed at the distal end of the tip of a flexible . . . tube or catheter which can be inserted into the body**. In one embodiment, only **a single high voltage wire** is necessary for operation." (col. 3, lines 25-28) "Preferably, the probe assembly includes **flexible fiber optical cable** 202 enclosed in a small-diameter flexible metallic tube 204."	Fig.s 5 and 6 illustrate a flexible probe having an x-ray tube as a distal end. Fig.s 5 and 6 also illustrate a flexible optical fiber having a bore through its length, and an electrical conductor extending through the bore of the optical fiber.

		(col. 7, lines 33-35) "A high voltage **conductor 208, embedded in the fiber optical cable 202,** conducts electrons to the cathode 222 . . . . The fiber optical cable 202 acts as an insulating dielectric between the **high voltage conductor 208** and the grounded flexible tube 204. . . . the **fiber optic cable 202 can have an annular configuration**. The light from the laser 220 travels down the **annular core of the fiber optic cabl**e 202. (col. 7, line 55 – col. 8, line 2)	
a second conductor on the outer surface of the optical fiber,	col. 2, lines 58-59; col. 7, lines 32-34; col. 7, line 58 - col. 8 line 5.	"The target and **outer surface of the probe** is preferably maintained at **ground potential** to reduce the risk of shock." (col. 2, lines 58-59) ". . . the probe assembly includes flexible fiber optical cable 202 **enclosed in a small-diameter flexible metallic tube** 204." (col. 7, lines 32-34) "Similarly, the flexible tube 204 couples a ground return from the target 228 to the high voltage source . . . The fiber optical cable 202 acts as an insulating dielectric between the high voltage conductor 208 and the grounded flexible tube 204. . . . the fiber optic cable 202 can have an annular configuration. The light . . . travels down the annular core of the fiber optic cable 202. Cladding can be provided on each side of the core . . . The **grounded flexible metal tube 204 can surround the outer cladding**." (col. 7, line 58 – col. 8, line 5)	

an essentially cylindrical tube formed of electrically insulative and X-ray transmissive material secured on a distal end of the optical fiber, the tube having a proximal end secured in a sealed connection to the outer wall of the optical fiber, at a position spaced back from the end of the optical fiber, and the tube having a distal end and defining a vacuum chamber within the tube,	Col. 2 lines 35-40; Col. 7 lines 35-51;	"The radiation source, at the distal end of the catheter, includes a **substantially rigid housing** disposed about a substantially evacuated interior region extending along a beam axis from an electron source at an input end of the housing to a radiation transmissive window at an output end of the housing." (col. 2, lines 35-40) "The radiation source **assembly 226** . . . extends from the end of the probe assembly 214 and **includes a shell** which encloses the target 228. According to one embodiment, the radiation source assembly 226 is rigid in nature and **generally cylindrical in shape**. In this embodiment the **cylindrical shell** enclosing the radiation source assembly 226 can be considered to provide a housing for the electron beam source as well as a tubular probe extending from the housing along the electron beam path." **The inner surface 226A of the assembly 226 is lined with an electrical insulator** , , , , . According to a preferred embodiment, **the radiation source assembly is hermetically sealed to the end of the probe assembly 214, and evacuated**. According to another embodiment, the entire probe assembly 214 is evacuated. (col. 7, lines 35-51)	
a cathode secured to the end of the optical fiber within the tube, the cathode	col. 3, lines 39-40; col. 3, lines 60-63; col. 7, lines 55-57;	"The x-ray source assembly 19 **has an electron source (cathode) 22 located in the distal end of the probe** 14." (col. 3, lines 39-40) "In the various forms of x-ray source assembly 19, the electron beam generator 22 may include a **thermionic emitter (driven by a** low voltage	

being electrically connected to said first conductor in the bore of the fiber, the cathode comprising a thermionic cathode which is excitable by heat to emit electrons,		power source or **laser**) . . . ." (col. 3, lines 60-63) "A **high voltage conductor 208, embedded in the fiber optical cable 202, conducts electrons to the cathode** 222 . . . . " (col. 7, lines 55-57)	
an anode formed within the tube near its distal end, and an anode conductor connecting said second conductor from the exterior of the optical fiber to the anode, with an X-ray target in the path of electrons moving from the cathode to the anode,	col. 4, lines 58-63; col. 7, lines 1-3	"As an example, a 0.5 mm wide **electron beam is emitted at the cathode and accelerated to 30 keV- through the anode**, with 0.1 eV transverse electron energies, and **arrives at the target assembly 26 downstream from the anode**, with a beam diameter of less than 1 mm at the target assembly 26. X-rays are generated in the target assembly 26 in accordance with preselected beam voltage, current, and target element 26B composition." (col. 4, lines 58-63)	
optical radiation means at the proximal end of the optical fiber	col. 7, lines 21-24; col. 3, lines 60-63;	Fig.s 5 and 6 show a diagrammatic view of radiation treatment apparatus 200 including a flexible probe 214. The apparatus 200 includes . . . **a laser (or other optical) source** 220 . . . . (col. 7, lines 21-24)	

for delivering optical radiation through the optical fiber, of sufficient power to heat the cathode so as to emit electrons, and		"In the various forms of x-ray source assembly 19, the electron beam generator 22 may include a **thermionic emitter (driven by a** low voltage power source or **laser)** . . . ." (col. 3, lines 60-63)	
means for selectively switching electrical power to the cathode and anode to establish a potential between the cathode and anode when desired, to thereby cause X-rays to be emitted outwardly from the tube.	col. 6, lines 1-7; col. 7, line 3 - col. 7, line 7;	"**X-rays are generated in the target assembly 26 in accordance with preselected beam voltage**, current, and target element 26B composition . . ." (col. 4, lines 63-65) " . . . a **high voltage power supply circuit 12A for establishing a drive voltage for the beam generator** 22 . . . . an associated controller 12C establishes control of the output voltage of the high power supply circuit" (col. 5, lines 11-15) ". . . the flexible tube 204 couples a ground return from the target 228 to the **high voltage source 219, thereby establishing a high voltage field between the cathode 216 and the target** 228." (col. 7, lines 59-62) "**The high voltage field between the cathode 222 and target 228 accelerates these electrons, thereby forcing them to strike the surface 228A of target 228 and produce x-rays.**" (col. 8 lines 12-15) "The radiation source . . .includes a substantially rigid housing . . . extending . . . to a radiation transmissive window at an output end of the housing. . . . The target produces x-radiation in response to incident	

		accelerated free electrons." (col. 2, lines 35-49).	
10. (New) A vascular probe according to claim 9, wherein the optical radiation means comprises a diode laser.		"In operation, the small **semiconductor laser** 220 shining down the fiber optical cable 202 activates the transmissive photocathode 222 . . . Such **diode lasers** are readily commercially available" (col. 8, lines 10-21).	
11. (New) A vascular probe according to claim 9, further including means for controlling the potential between the cathode and the anode to control the level of X-ray output from the tube.		"The **high voltage power supply** 12A in each of the illustrated embodiments preferably satisfies three criteria: 1) small in size; 2) high efficiency to enable the use of battery power; and 3) **independently variable x-ray tube voltage** and current to enable the unit to be programmed for specific applications. A **high-frequency, switch-mode power converter** is used to meet these requirements." (col. 6, lines 1-7) "The **controller 12C controls the power supply 12A to dynamically adjust the cathode voltage**, the electron beam current, and temporal parameters, or to provide pre-selected voltage, beam current, and temporal parameters. (col. 7, line 3 - col. 7, line 7)	
12. (New) A vascular probe according to claim 9, wherein the anode includes the X-		Fig.s 5 and 6, and supporting description (col. 7, line 22 - col. 8, line 42) disclose embodiments in which the anode and target are not separate elements, but the anode includes the target.	

ray target.			
13. (New) A vascular probe having an X-ray tube as a distal end, comprising: a flexible optical fiber, a first electrical conductor embedded in and extending through the length of the optical fiber, a second conductor on the outer surface of the optical fiber, an X-ray tube formed of electrically insulative material on a distal end of the optical fiber, the tube having a proximal end in sealed relationship with	<u>See</u> citations above relating to claim 9.	<u>See</u> description above relating to claim 9.	

the outer wall of the optical fiber, and the tube having a distal end and defining a vacuum chamber within the tube between the ends of the tube, a cathode at the end of the optical fiber within the tube, the cathode being electrically connected to said first electrical conductor in the fiber, the cathode comprising a thermionic cathode which is excitable by heat to emit electrons, an anode formed with in the tube near its distal end, and an anode conductor connecting said second conductor			

from the exterior of the optical fiber to the anode, with an X-ray target in the path of electrons moving to the anode, optical radiation means at the proximal end of the optical fiber for delivering optical radiation through the optical fiber, of sufficient power to heat the cathode so as to emit electrons, and means for selectively switching electrical power to the cathode and anode to establish a potential between the cathode and			

anode when desired, to thereby cause electrons to strike the target to cause X-rays to be emitted from the tube.			
14. (New) A vascular probe according to claim 13, wherein the anode includes the X-ray target.	<u>See</u> citations above relating to claim 9.	<u>See</u> description above relating to claim 9.	
15. (New) A flexible probe having an x-ray tube at its distal end, comprising: A. a flexible optical fiber adapted for transmitting optical radiation incident on a proximal end to a	col. 1, lines 11-15; col. 2, lines 17-19; col. 2, lines 32-37; col. 3, lines 25-28; col. 7, lines 33-35.	<u>See</u> specification text reproduced above that correspond to these citations.	

distal end;			
B. an optical source for generating optical radiation directed to said proximal end of said optical fiber;	col. 3, lines 60-63; col. 7, lines 21-24	<u>See</u> specification text reproduced above that correspond to these citations.	
C. an x-ray tube coupled to said distal end of said optical fiber, comprising: a. a thermionic cathode, responsive to optical radiation transmitted to said distal end of said optical fiber and incident upon a surface of said cathode to generate electrons; and b. an x-ray target responsive to incident electrons emitted	col. 2, lines 35-40; col. 3, lines 39-40; col. 3, lines 60-63; col. 7, lines 35-51	<u>See</u> specification text reproduced above that correspond to these citations.	

from said thermionic cathode to emit x-rays; and			
D. means for accelerating electrons emitted from the thermionic cathode toward said x-ray target; wherein said beam of transmitted optical radiation has a power level sufficient to heat at least a portion of said surface to an electron emitting temperature so as to cause thermionic emission of electrons from said surface.	col. 3, lines 60-63; col. 5, lines 11-15; col. 7, lines 59-62	See specification text reproduced above that correspond to these citations.	
16. (New) A vascular probe	col. 1, lines 11-15; col. 2, lines 17-19;	See specification text reproduced above that correspond to these citations.	

having an x-ray tube as a distal end, comprising: A. an optical source for generating optical radiation, B. a flexible optical fiber having a proximal end and a distal end, and adapted for transmitting optical radiation from said optical source from said proximal end to said distal end; C. an x-ray tube coupled to a distal end of said optical fiber, comprising a substantially rigid housing defining a substantially evacuated interior region extending	col. 2, lines 32-37; col. 2, lines 35-40; col. 3, lines 25-28; col. 3, lines 39-40; col. 3, lines 60-63; col. 5, lines 11-15; col. 7, lines 21-24; col. 7, lines 33-35; col. 7, lines 35-51 col. 7, lines 59-62		

between a proximal end and a distal end of said housing, said housing containing a thermionic cathode and an x-ray target between its proximal and distal ends, said distal end of said housing comprising x-ray transmissive material; a. wherein the thermionic cathode is responsive to said optical radiation transmitted to said distal end to emit electrons; and b. wherein said x-ray target is responsive to incident			

electrons emitted from said thermionic cathode to emit x-rays whereby said x-rays are directed through said x-ray transmissive material of said housing; D. means for accelerating electrons emitted from the thermionic cathode toward said x-ray target; wherein said optical fiber is adapted to direct a beam of optical radiation transmitted therethrough to impinge upon a surface of the thermionic cathode, and wherein said beam of			

transmitted optical radiation has a power level sufficient to heat at least a portion of said surface to an electron emitting temperature so as to cause thermionic emission of electrons from said surface.			
17. (New) A brachytherapy treatment apparatus, comprising: A. a flexible probe including an optical fiber adapted for transmitting optical radiation incident on a proximal end to a distal end; B. an optical source for	col. 1, lines 42-55; col. 1, lines 57-63; col. 6, lines 27-37; col. 1, lines 11-15; col. 2, lines 17-19; col. 2, lines 32-37; col. 3, lines 25-28; col. 7, lines 33-35 col. 3, lines 60-63; col. 7, lines 21-24; col. 2, lines 35-40; col. 3, lines 39-40; col. 3, lines 60-63;	Col. 1, lines 42-55, col. 1, lines 57-63, and col. 6, lines 27-37 relate to brachytherapy and treating tumorous targets, and are reproduced below. The specification text corresponding to the other citations relating to claim 17 have already been reproduced above. " An alternative treatment system utilizing a point source of radiation is disclosed in U.S. Pat. No. 5,153,900 issued to Nomikos et al., U.S. Pat. No. 5,369,679 to Sliski et al., and U.S. Pat. No. 5,422,926 to Smith et al., all owned by the assignee of the present application, all of which are hereby incorporated by reference. This system includes a miniaturized, insertable probe capable of producing low power radiation in predefined dose geometries disposed about a predetermined location. This type of treatment is referred to as brachytherapy because the source is located close to or in some cases within the area receiving treatment. One advantage of brachytherapy is that the radiation is applied primarily to treat a predefined tissue volume, without significantly affecting the tissue adjacent to the	

generating optical radiation directed to said proximal end of said optical fiber; C. an x-ray tube coupled to said distal end of said flexible probe, comprising: a. a thermionic cathode, responsive to optical radiation transmitted to said distal end of said optical fiber and incident upon a surface of said cathode to generate electrons; and b. an x-ray target responsive to incident electrons emitted from said thermionic cathode to emit a therapeutically effective amount	col. 7, lines 35-51 col. 3, lines 60-63; col. 5, lines 11-15; col. 7, lines 59-62	treated volume." (col. 1, lines 42-55) "Typical radiation therapy treatment involves positioning the insertable probe into or adjacent to the tumor or the site where the tumor or a portion of the tumor was removed to treat the tissue adjacent the site with a "local boost" of radiation. In order to facilitate controlled treatment of the site, it is desirable to support the tissue portions to be treated at a predefined distances from the radiation source." (col. 1, lines 57-63) "In all of the above-described embodiments, the x-ray emission element of the target assembly is adapted to be adjacent to or within the region to be irradiated. The proximity of the emission element to the targeted region, e.g. the tumor, eliminates the need for the high voltages of presently used machines, to achieve satisfactory x-ray penetration through the body wall to the tumor site. The low voltage also concentrates the radiation in the targeted tumor, and limits the damage to surrounding tissue and surface skin at the point of penetration." (col. 6, lines 27-37)	

of x-rays toward a tumorous target, in a predetermined spectral range; and D. means for accelerating electrons emitted from the thermionic cathode toward said x-ray target; wherein said optical fiber is adapted to direct optical radiation transmitted therethrough onto a surface of the thermionic cathode, and wherein said beam of transmitted optical radiation has a power level sufficient to heat at least a portion of said surface to an electron			

emitting temperature so as to cause thermionic emission of electrons from said surface.			
18. (New) A x-ray treatment apparatus, comprising: A. a flexible fiber optic assembly, including an optical fiber adapted for transmitting light incident on a proximal end of the fiber to a distal end of the fiber; B. an optical source for generating optical radiation directed to said proximal end of	col. 1, lines 11-15; col. 2, lines 17-19; col. 2, lines 32-37; col. 2, lines 35-40; col. 3, lines 25-28; col. 3, lines 39-40; col. 3, lines 60-63; col. 5, lines 11-15; col. 7, lines 21-24; col. 7, lines 33-35; col. 7, lines 35-51 col. 7, lines 59-62	<u>See</u> specification text reproduced above that correspond to these citations.	

said optical fiber; C. a power supply including a first terminal and a second terminal, and means for establishing an output voltage between the first terminal and the second terminal; and D. an x-ray target assembly affixed to the distal end of the optical fiber and electrically coupled to the power supply by way of the first terminal and the second terminal, the x-ray target assembly including an x-ray target having at least one x-ray emissive element for emitting x-			

ray radiation in a predetermined spectral range in response to said optical radiation transmitted to the distal end of the optical fiber.			
19. (New) An x-ray treatment apparatus in accordance with claim 18, wherein said x-ray target assembly includes a substantially rigid housing defining a substantially evacuated interior region extending along a beam axis between an electron source at an input end of the housing and an x-ray	Col. 2, lines 35-49; Col. 7, lines 35-51	<u>See</u> specification text reproduced above that correspond to these citations.	

transmissive window at an output end of the housing, the housing having said x-ray target disposed adjacent said x-ray transmissive window, the housing having the input end affixed to the distal end of the catheter, the electron source being adapted to generate electrons in response to said optical radiation transmitted through the optical fiber; wherein upon activation said power supply establishes an accelerating electric field between said x-			

ray emissive element and said electron source, the electric field acting to accelerate electrons emitted from said electron source toward said x-ray target; and wherein said x-ray target is responsive to incident accelerated free electrons to emit x-ray radiation whereby the x-ray radiation emitted therefrom is directed through the x-ray transmissive window.			
20. (New) An x-ray treatment apparatus in	col. 3, lines 60-63; col. 7, lines 21-24; col. 8, lines 1021;	Col. 7, lines 52-55, and col. 8, lines 26-29 relate to a photocathode, and are reproduced below. The specification text corresponding to the other citations relating to claim 20 have already been reproduced above.	

accordance with claim 21, wherein said optical source comprises a laser; and wherein said electron source includes at least one of: a) a laser-driven thermionic emitter; and b) a photocathode.	col. 7, lines 52-55; col. 8, lines 26-29	"The terminal end 202A of the fiber optical cable 202 is preferably coated, over at least part of its area, with a semitransparent photoemissive substance such as, Ag--O--Cs, thus forming a photocathode 222." (col. 7, lines 52-55) "One difficult fabrication aspect of this invention is the fabrication of the photocathode 222, which for practical substances, with reasonable quantum efficiencies above 10^{-3}, should be performed in a vacuum." (col. 8, lines 27-30).	
21. (New) A probe having an x-ray tube as a distal end, comprising: a flexible optical fiber; a tube secured on a distal end of said optical fiber, said tube having a distal end and a proximal end, said tube comprising x-ray transmissive	col. 1, lines 11-15; col. 2, lines 17-19; col. 2, lines 32-37; col. 2, lines 35-40; col. 3, lines 25-28; col. 3, lines 39-40; col. 3, lines 60-63; col. 5, lines 11-15; col. 7, lines 21-24; col. 7, lines 33-35; col. 7, lines 35-51 col. 7, lines 59-62	<u>See</u> specification text reproduced above that correspond to these citations.	

material and defining a vacuum chamber within the tube; a cathode within said tube and secured to said end of said optical fiber, said cathode comprising a thermionic cathode which is excitable by heat to emit electrons; and means for selectively providing electric power to said cathode and said x-ray target to establish a potential between the cathode and the x-ray target when desired, to thereby cause x-rays to be emitted outwardly from			

the tube.			